Clean Technologies and Environmental Policy (2021) 23:749–764
https://doi.org/10.1007/s10098-020-01909-9

ORIGINAL PAPER

Features influencing policy recommendations for the promotion of zero-emission vehicles in Slovenia, Spain, and Poland

Matjaz Knez[1] · Borut Jereb[1] · Eulalia Jadraque Gago[2] · Joanna Rosak-Szyrocka[3] · Matevz Obrecht[1]

Received: 19 December 2019 / Accepted: 30 July 2020 / Published online: 29 August 2020
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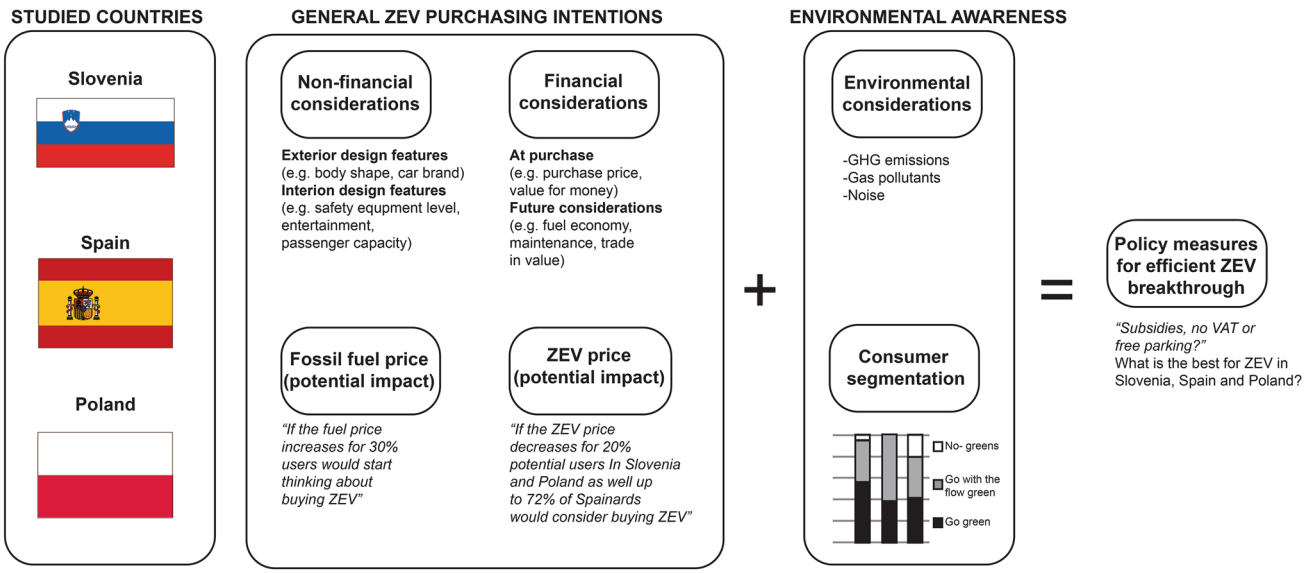
Abstract

To make society more sustainable, cleaner transportation technologies, such as zero-emission vehicles and sustainable mobility, are being investigated, promoted, and supported by different policy measures. The emphasis of this paper is determining the zero-emission vehicle features that can influence specific policy recommendations; this understanding can boost zero-emission vehicle use as a potential cleaner transportation technology among different consumer segments in different EU member states. A customer-oriented study of over 1500 Slovenians, Spaniards, and Poles revealed the most relevant zero-emission vehicle-purchasing features are: (a) vehicle price and (b) fuel economy. The percentage of potential zero-emission vehicle buyers is said to rise to 80% should the price of electric cars decrease and fuel price increase accordingly, i.e. by 30% and 50%, respectively. Concerning the car price, Slovenian and Polish consumers' preferences are similar, and 40% of them (and up to 85% of Spaniards) would consider buying one if the price drops by 25%. Women in all three studied countries are more interested in zero-emission vehicles than men are. Different policies should be used in Poland, where people are not as interested in zero-emission vehicles as Spanish and Slovenian consumers are. Customer segmentation in all three groups pointed out that Poland has the highest share (19%) of "No-green" consumers, whereas Spain has the highest share (60%) of "Go-green" consumers, i.e. consumers who would consider buying a zero-emission vehicle in the foreseeable future.

Graphic abstract



Keywords Zero-emission vehicles · Sustainable transportation technologies · Consumer segmentation · Sustainable consumption · Policy measures

Extended author information available on the last page of the article

Introduction

Consumers are mostly very reluctant to let go of their standard of living related to their primary means of transportation and their strong feelings of independence associated with personal car use (Anderson and Stradling 2004). It is, therefore, essential to promote zero-emission driving since transportation is a significant source of greenhouse gasses (GHGs) and other pollutants such as CO, NO*x*, PM, SO*x*, and heavy metals (Fan et al. 2018; Baleta et al. 2019). It contributes 14% of all global GHG emissions (Lee et al. 2018), mostly as a consequence of road transportation (Fan et al. 2018). Alternative sustainable technologies, as such, are one possible solution, and transforming consumer habits and lifestyles are another (Kramberger et al. 2014; Cramton et al. 2018; McCollum et al. 2017; Sopjani et al. 2018). In this respect, unveiling the consumers' attitudes, preferences, and decision factors towards zero-emission vehicles (ZEVs) is necessary for the formulation of effective policy measures, the effective commercialization and promotion of ZEVs for post-fossil and more sustainable personal transportation (Bockarjova and Steg 2014; Komiyama and Kraines, 2008; Fan et al. 2018) that has become "an embraced goal" of many countries around the world.

It is believed that different ZEVs are a viable near-term transportation technology capable of providing more sustainable personal mobility, especially in cases of dispersed population, and hold many promises: from reducing dependence on imported petroleum to decreasing GHG emissions (Rodrigues Teixeira and Sodre 2018; Turcksin et al. 2013) as well as some other environmental concerns reflected in healthier living environments and reducing noise pollution. However, mainstream adoption has not yet been achieved regardless of the international, national, and local incentives, along with enticing promises to solve these severe problems. ZEVs have some technological weaknesses [e.g. range of electric vehicles (EV), hydrogen storage in hydrogen fuel cell vehicles (HFCV) (Thesen and Langhelle 2008), energy losses]; they still cost more than petrol-powered vehicles do; they require new infrastructure to be established (National Academy of Sciences 2013; Knez et al. 2019); and their environmental benefits are debatable, especially regarding the electricity mix for charging (Ajanovic and Haas 2019). These issues are sometimes identified as key barriers to greater ZEV commercialization. However, this is not necessarily true for all of them since over 95% of drivers use cars for daily trips/rides for up to 50 km (Knez and Obrecht 2015); therefore, range or charging infrastructure is not the core problem of ZEVs for the majority of potential users. A review of studies from the previous decade on customer-oriented studies of ZEV and low-emission vehicle (LEV) is summarized in Table 1.

Concerning the literature reviewed, it must be noted that the "social" barriers may pose as much of a problem as the "technical" ones in the development of ZEVs for the mainstream consumer market. Although purchasing decisions have been thoroughly studied, the research was focused mostly separately on financial or performance features, carried out for LEVs, EVs, gas-powered vehicles, etc., performed in one country only and without potential user segmentation. The authors have not found any study dealing with the impact of different financial as well as non-financial features on ZEV-purchasing intentions regarding different segments of potential users within different geographically distant but similarly developed countries. Investigating the impact of financial and technical features of ZEV in three different EU member states (Slovenia, Spain, and Poland) and examining their potential impact to use it for more efficient ZEV promotion policies were also the primary motivation for this survey. Since it was assumed that differences occur among different segments, even inside each state, segmentation was also performed, studied, and discussed. To define and set an appropriate mix of measures within promotion policies for greater use of ZEVs, countries' specifics, consumer segmentation, and acceptance of different promotional measures must first be examined and well understood. This paper's objectives are, therefore, to achieve the following:

- Examine the impacts of key performance and financial features regarding ZEVs in Slovenia, Spain, and Poland and cross-compare the most and least important features since vehicle purchasing or renewal varies regarding consumer behaviour, which is different in different geographic areas (Andre et al. 2018);
- Evaluate the impact of fossil fuel potential price increase and ZEV potential price decrease on customers' demand and willingness to buy ZEVs (it is believed that ZEV demand varies in dependence with fossil fuel prices and the price of alternative powertrains);
- Identify three segments of potential ZEV users: "No-greens" (not interested in ZEVs); "Go-with-the-flow greens" (the largest and most promising segment for car manufacturers); and "Go-greens" (the segment with the highest environmental awareness, already interested in ZEVs and already considering buying or using one in the near future);
- Analyse the differences between Slovenia, Spain, and Poland as EU member states in different geographical areas of the EU to propose the most appropriate promotional policies and measures for the greater implementation of ZEVs.

Table 1 Review of studies on customer-oriented studies of ZEV and low-emission vehicle (LEV) from 2009 to 2019

References	Geographical area (if any)	Main findings and research focus
Popp et al. (2009)	USA, EU	When people are choosing a new car, fuel prices are of great importance. The importance of fuel economy is even higher when potential users believe they can influence the environment positively
Flamm (2009)	USA (California)	Environmental knowledge and attitudes are related to owning LEVs or ZEVs
Martin et al. (2009)	USA (California)	Approximately 480 km range of EVs is good enough to be accepted by 90% of potential EV users. HEVs are identified as a possible solution for users that need longer ranges
Diamond (2009)	USA	Some common barriers to the adoption of ZEVs include lack of knowledge by potential consumers, high initial costs, and low-risk tolerance
Achterberg et al. (2010)	Netherland	Three most important features for purchasing new hybrid cars in Netherland are environmental concern, and the related need to take care of nature, as well as trust in alternative technology
Van de Velde et al. (2010)	Belgium	Men, higher educated people, people between 35 and 54 years old, and people with the most pro-environmental attitude are less affected by the message of sustainability, while the choice of this is more important when addressing women, people younger than 35 and older than 55 years, lower educated, and less pro-environmental people
Axsen et al. (2010)	USA	Performance requirements of EVs batteries are closer to being commercially viable than expected
Turrentine et al. (2011)	USA	Research shows that customers doubt that ZEVs are powerful enough for highways or safe in different weather conditions and puddles and if they are actually any better for the environment than internal combustion vehicles
Egbue and Long (2012)	Not specified	The charging infrastructure is now one of the major challenges faced by EVs, and the most promising benefit is the possibility of home charging, quiet ride, and low maintenance costs. Non-financial features associated with energy can influence consumers' decisions, but in the case of financial benefits, they are more likely to focus on their knowledge of alternatives, preferences, and budget
Knez et al. (2014)	Slovenia	The most relevant factor for purchasing a low-emission vehicle is the total vehicle price. Low-emission vehicles are, surprisingly, also more attractive for the older population. People would choose low-emission vehicles mainly based on very low running costs rather than any environmental benefit
Krupa et al. (2014)	USA	The realization of expected contributions to sustainability ultimately falls on the consumers' willingness to purchase the new technology. Climate change awareness also brings a greater willingness to consider buying EVs
Barth et al. (2016)	Germany	The most important feature related to the adoption of EVs is the purchasing price, followed by the oil price
Yadav and Pathak (2016)	India	Environmental concern emerged as the most significant predictor of green purchase intention
McCollum et al. (2017)	Not specified	Stronger price-based incentives and/or non-price-based measures may be needed to transform the global fleet of passenger vehicles, at least in the initial market phases of novel alternatives
Egbue et al. (2017)	Not specified	It is also important that any engineering and technology background is identified in a potential user since they are more open to buying EVs than the general public is
Andre et al. (2018)	France (Paris)	Consumer behaviour can be different in different geographic areas
Lina and Wu (2018)	China (Beijing, Shanghai, Guangzhou, and Shenzhen)	Attitude factors such as network externality, price acceptability, government subsidies, vehicle performance, environmental concerns, and demographic characteristics such as gender, age, and marital status have significant impact on respondents' willingness to purchase electric vehicles
Zhou et al. (2019)	China	Taxation preference had better performance in incentivizing EVs than the direct subsidy, which is contrary to current political discourses
Makarova et al. (2019)	Russia	Technological forecasts based on ZEV-related research are also crucial for top managers of industry-leading carmakers, who steer the automotive industry towards a transition to a more sustainable future
Amatulli et al. (2019)	Not specified	The companies' communication strategies itself might be the trigger that induces customers to buy a green product

The primary purpose of this study is, therefore, to present a valuable insight for sustainable transportation policymakers, car manufacturers deciding on their ZEV priorities, and for sustainable mobility developers.

The remainder of the paper is structured as follows: in the following section, information on materials and methods including background information on the analysed countries, data gathering, and studied features for the analysis is given. In the result section, a descriptive analysis of non-financial and financial considerations is presented, followed by the impact of a potential oil price increase and ZEVs' price decrease. Further potential ZEV users are segmented from No-greens to Go-greens, and policy measures enabling ZEV expansion are cross-compared. The discussion is integrated into the results section to derive implications for policymakers as well as car manufacturers. A short conclusion completes the paper.

Materials and methods

Analysed countries

The first step was the identification and selection of the countries included in the study. This study is a comparative analysis of purchasing intentions in Slovenia, Spain, and Poland—three EU member states that differ regarding geographical location and regarding gross national income per capita (GNI).

Slovenia, a country in central Europe, and Poland, a country in north-eastern Europe, both are younger EU Member States, and Spain, a Mediterranean country in south-western Europe, that is also an older EU Member State. We believe that the geographic location of countries affects people's habits; also, all three countries had totalitarian regimes before the transition to democracy, which is why we believe that transition and thinking about alternative mobility are similar and different from countries that have been democratic for a long time.

The countries are quite comparable also regarding their per capita gross national income (GNI) (in 2018 Slovenia: €24,800; Poland: €20,100, and Spain: €27,700) (Eurostat 2019a). Regarding the policy and market setting, we believe that Slovenia and Poland, which entered the EU simultaneously and adjusted their legislation to the European Union later than Spain (as an older EU member) did, can also affect the dynamic of people's perception and the adoption of alternative mobility solutions, which can also be reflected in various areas, such as the economy, education system, and the presence of environmental topics in the media, which affects the diversity of Spain, which has been a member of the EU for a longer time. Additionally, all three studied countries have quite similar population density (approximately 90 people/km^2 in Spain, approximately 102 people/km^2 in Slovenia, and 120 people/km^2 in Poland) (Eurostat 2019b) with highly randomly dispersed populations in most of their regions (and throughout the whole of Slovenia) in towns where public transport is far from ideal, which means that a high share of the population must take a car to work, school, and on their daily routines.

Data gathering

The collected data consist of primary and secondary data. Secondary data gathered with reviewing relevant literature, e.g. statements and results regarding ZEVs, were extracted from studies focused on EVs, ZEVs, HFCVs, as well as LEVs. In the case of LEV studies, we excluded results related to biofuels and natural/petroleum gas-powered vehicles. For the primary data collection, a pre-structured questionnaire derived from the research of Borthwick and Carreno (2012) on green taxes and green tax incentives and legislation was used and distributed in Slovenia, Spain, and Poland. Part of this questionnaire was identified to be potentially interesting for research on consumer behaviour and the importance of ZEV performance features on consumers' purchasing decisions. When using a standardized questionnaire, comparable results are obtained and allow (also long-term) monitoring of selected research issues and gathered data (also to analyse the time series). The research was conducted from 2015 to 2017. The data gathered were statistically analysed and cross-compared.

This survey population covers people currently owning a vehicle, as well as those who currently do not own a car but have daily access to one if and when they need it. People younger than 18 years old and people with no driving licence or without the possibility of using a vehicle were excluded from the survey. The focus group was adults with driving licences, because others are presumably more interested in public transport than having a personal ZEV. The sample includes 817 participants from Slovenia, 337 participants from Spain, and 352 participants from Poland, whose purchasing intentions and relevant ZEV performance features were studied.

A total of 94% of study participants currently own/have access to a car in Slovenia, and 91% do so in Spain and Poland. The age group from 18 to 24 years presumably does not own a car (or does so to a lesser extent); therefore, they may also have a different perspective on ZEVs and are potential users. The educational structure was also examined and was found to be similar in all the countries studied.

The data gathered from Slovenia, Spain, and Poland were all statistically analysed and cross-compared. Key

similarities and differences of the studied features influencing the purchasing intentions for ZEV in studied countries were additionally analysed and discussed. Secondary data were collected using the compilation method, from numerous scientific and professional references focused on the current research topic.

Limitations of the study were identified as being the limited time frame (2017) and the potential subjectivity of answers (i.e. personal opinions). These can be dynamic and vary in time. The statistical sample may also not completely accurately reflect the whole population.

Studied ZEV features

The collected data were processed and analysed with SPSS statistical software. Cluster analysis was used for data classification, carried out by dividing and synthesizing the data into groups. For data analysis, principle component factor analysis enrolled to limit situational variables (attributes) was adapted from Borthwick and Carreno (2012) and was divided into the seven broad features presented in Table 2.

Financial consideration related to changing petrol prices and potential changes in ZEV were also investigated as being of core importance for the future purchasing intentions by numerous authors (Andre et al. 2018; Barth et al. 2016; Popp et al. 2009).

Results

The willingness to buy ZEVs differs significantly regarding various features. Their technical limitations, such as occasionally insufficient charging infrastructure (for EVs, HFCVs, etc.) or limited performance of some types of ZEV (e.g. EV range, the electric range for PHEVs and HEVs, hydrogen storage, etc.), are often identified as significant barriers to ZEV commercialization. Nevertheless, because more ZEVs with better performance are being launched on the market (EVs with improved range, HFCVs with improved charging and hydrogen storage, etc.) each year as well as rapid installations of numerous charging stations (public and private), it can be forecast that ZEVs will boost already in 2020.

Table 2 Important features for future vehicle-purchasing intentions. (Adapted from Borthwick and Carreno 2012)

Features	Attributes
Financial considerations at the time of purchase	Vehicle price VAT and other purchase taxes Value for money
Future financial considerations	Insurance group for vehicle Maintenance/repair costs Warranty (length and coverage) Biannual/annual vehicle excise duty (VED) Trade-in value
Fuel and performance	Fuel consumption (miles per gallon/kilometres per litre) Engine type/size Fuel type Fuel economy Performance/drivability
Exterior design features	Vehicle make Model of vehicle Vehicle size Style/appearance/colour
Interior design features	Safety features Security features Equipment levels Entertainment system Acceleration time
Load space	Luggage/storage space Passenger capacity Body style
Environmental awareness	Emissions of CO_2 and other GHG Emissions of other air pollutants Vehicle noise

Non-financial considerations

Two non-financial features are crucial when analysing purchasing intentions: "overall condition and mileage of vehicle (e.g. especially when consider buying a used vehicle)", and "safety features". Other important features are body style (e.g. hatchback, coupe), fuel type/type of vehicle, vehicle size (exterior), and style/appearance/colour. Research results for Slovenia, Spain, and Poland are presented in Fig. 1.

The results indicate that there are some differences among the studied countries, especially regarding fuel type and acceleration. Fuel type is much more important for Spanish consumers than for their Polish and Slovenian counterparts, and acceleration is much less important for Slovenian buyers than for Spanish and Polish ones. Table 3 shows the three most influential and three least influential "non-financial" features relevant to future car-purchasing decisions by country. These features are accompanied by the data of mean (M), standard deviation (SD), and standard error of the mean (SEM).

There are some similarities but even more differences. For example, "safety features" are considered to be a very important feature in all three countries. However, the interesting point revealed in this research is that women see safety more relevant than men do in all three studied countries (average grade for Slovenia: women 6.33 and men 5.85; average grade for Poland: women 6.28 and men 5.77; average grade for Spain: 6.73 and men 6.45). While safety is of greater importance for women, it is interesting that they also cause fewer traffic accidents (Topolsek 2007). Other factors differed: Slovenia and Spain both have "equipment levels" at third place and Spain and Poland have "style/appearance/colour" at third and second places, but no other significant similarities were recognized. "Fuel type" was much more important for Spain, and "overall condition and mileage of vehicle" was more important for Slovenian and Polish respondents. It can be speculated that this is a reflection that more used cars are sold on Slovenian and Polish markets; therefore, this feature is more important in these two countries.

Table 3 also proves that the more important non-financial features have a bit lower standard deviation than the less important ones do. The obtained data are therefore closer to the means and the standard error of the mean is lower. Probably, respondents give more attention to more important features (according to the less important features) and are, therefore, more certain about their decision in a certain area (country). However, it is entirely possible for one distribution to have a larger standard deviation than another distribution, while each person in the distribution with the larger standard deviation is as or more certain of their position than the individuals in the distribution with the smaller standard deviation. The scale the authors use measures only importance, not how certain the respondent is about their reply.

Financial considerations

When it comes to financial features, there are visible similarities between Slovenia and Poland, where the three most influential features are "Fuel economy", "The total price of the vehicle", and "Maintenance/repair costs". "Fuel economy" is also a priority in Spain, and this feature is crucial, especially nowadays since oil prices are high and still increasing. "Value for money" and "Trade-in value" seem to be especially important in Spain. "Warranty" and "Methods of payment" also have significantly higher grades in Spain. These features indicate that Spanish

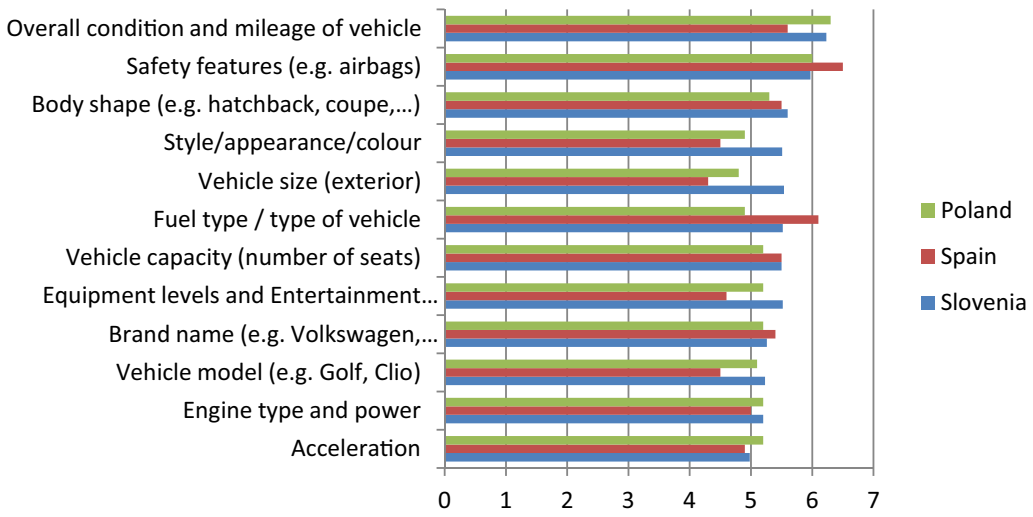


Fig. 1 Important vehicle performance features in Slovenia, Spain and Poland (on a scale from 1 to 7, where 1 means NOT IMPORTANT and 7 means VERY IMPORTANT)

Table 3 Three most important and three least important non-financial features for future car-purchasing decisions in Slovenia, Spain, and Poland with M, SD, and SEM

	Slovenia	Spain	Poland
Three most important non-financial features			
1	Overall condition and mileage of vehicle (if you buy a used car)	Safety features (e.g. airbags)	Overall condition and mileage of vehicle (if you buy a used car)
	$M = 6.230$	$M = 6.608$	$M = 6.321$
	SD = 0.947	SD = 0.995	SD = 1.025
	SEM = 0.036	SEM = 0.054	SEM = 0.061
2	Safety features (e.g. airbags)	Fuel type	Safety features (e.g. airbags)
	$M = 5.970$	$M = 6.156$	$M = 6.040$
	SD = 1.107	SD = 1.256	SD = 1.175
	SEM = 0.042	SEM = 0.069	SEM = 0.070
3	Car body style (e.g. hatchback. coupe)	Overall condition and mileage of vehicle (if you buy a used car)	Car body style (e.g. hatchback. coupe)
	$M = 5.611$	$M = 5.668$	$M = 5.325$
	SD = 1.474	SD = 1.515	SD = 1.469
	SEM = 0.056	SEM = 0.083	SEM = 0.087
Three least important non-financial features			
1	Acceleration	Vehicle size (exterior)	Vehicle model (e.g. Golf. Clio)
	$M = 4.891$	$M = 4.280$	$M = 4.515$
	SD = 1.462	SD = 1.800	SD = 1.832
	SEM = 0.056	SEM = 0.099	SEM = 0.101
2	Engine type and power	Vehicle model (e.g. Golf. Clio)	Style/appearance/colour
	$M = 4.588$	$M = 4.515$	$M = 4.888$
	SD = 1.255	SD = 1.831	SD = 1.701
	SEM = 0.048	SEM = 0.101	SEM = 0.101
3	Vehicle model	Style/appearance/colour	Equipment levels
	$M = 4.689$	$M = 4.515$	$M = 4.921$
	SD = 1.497	SD = 1.832	SD = 1.534
	SEM = 0.057	SEM = 0.101	SEM = 0.090

purchasers are different from their Slovenian and Polish counterparts and are much more interested in financial features correlating long-term security related to value for money. In contrast, similarities between Slovenia and Poland are evident.

A less important feature in all three countries seems to be "Annual road tax".

The average grade for individual financial features was similar in Slovenia and Poland with clear differences among potential Spanish ZEV buyers (Fig. 2). The three most important and three least important "financial" features of ZEVs are presented in Table 4. "Total vehicle price" was found to be the most important financial feature for participants from Slovenia and second most important for Poland. For Spaniards, "total vehicle price" was among the three least important features. In contrast, "Annual road tax" and "Methods of payment" are the least important features in all three countries. (However, "Methods of payment" does have a much higher average grade in Spain.) Therefore, these two measures should not be enforced for the promotion of ZEVs because they appear to have a relatively small impact on purchasing decisions.

The same conclusions as for Table 3 can also be seen from the data in Table 4: standard deviations at most important features represent more concentrated values around the mean value than in case of least important, for which the values are more dispersed around the mean value.

From Fig. 2 and Table 4, it can be seen that the three observed markets have certain similarities and, more importantly, also differences that must be taken into account by government authorities when promoting low-emission vehicles and by car manufacturers and retailers when designing marketing strategies for such vehicles.

T-tests (two-tailed tests with means paired) on the mean and standard deviation values of the above-described features in Figs. 1 and 2 are represented in Fig. 3. A three-time T test on two sets of mean values for each non-financial feature in Fig. 1 shows that data from Slovenia and Poland are not significantly different; a more significant difference is found between mean values between Slovenia and Spain,

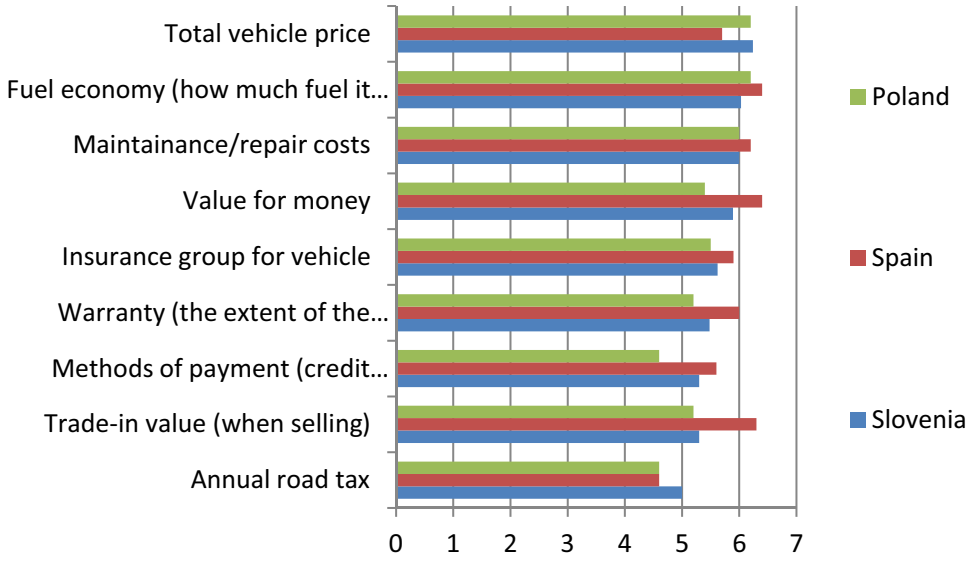


Fig. 2 Important financial considerations in Slovenia, Spain, and Poland (on a scale from 1 to 7, where 1 means NOT IMPORTANT and 7 means VERY IMPORTANT)

Table 4 Three most important and three least important financial features for the future car-purchasing decisions in Slovenia, Spain, and Poland with M, SD, and SEM

	Slovenia	Spain	Poland
The three most important financial features			
1	Total vehicle price	Value for money	Fuel economy
	$M = 6.367$	$M = 6.449$	$M = 6.196$
	SD = 0.945	SD = 0.900	SD = 1.108
	SEM = 0.036	SEM = 0.049	SEM = 0.068
2	Fuel economy	Fuel economy	Total vehicle price
	$M = 6.196$	$M = 6.422$	$M = 6.187$
	SD = 1.113	SD = 1.001	SD = 1.078
	SEM = 0.042	SEM = 0.055	SEM = 0.066
3	Maintenance/repair costs	Trade-in value	Maintenance/repair costs
	$M = 5.954$	$M = 6.286$	$M = 6.000$
	SD = 1.258	SD = 1.132	SD = 1.092
	SEM = 0.048	SEM = 0.062	SEM = 0.066
Three least important financial features			
1	Annual road tax	Annual road tax	Annual road tax
	$M = 4.678$	$M = 4.596$	$M = 4.558$
	SD = 1.634	SD = 1.877	SD = 1.548
	SEM = 0.062	SEM = 0.103	SEM = 0.095
2	Trade-in value	Methods of payment	Methods of payment
	$M = 4.747$	$M = 5.589$	$M = 4.595$
	SD = 1.560	SD = 1.563	SD = 1.783
	SEM = 0.059	SEM = 0.086	SEM = 0.109
3	Methods of payment	Total vehicle price	Warranty
	$M = 4.896$	$M = 5.720$	$M = 5.177$
	SD = 1.762	SD = 1.514	SD = 1.681
	SEM = 0.067	SEM = 0.083	SEM = 0.103

and the most significant difference between mean values of non-financial values is between Spain and Poland. In contrast, these differences are smaller in the case of financial features. The *T* test on standard deviations of non-financial features shows almost identical relationships between country pairs, as in the case of the *T* test on the mean, while in the case of financial features we are faced with the opposite situation: the *T* test shows that standard deviations for financial

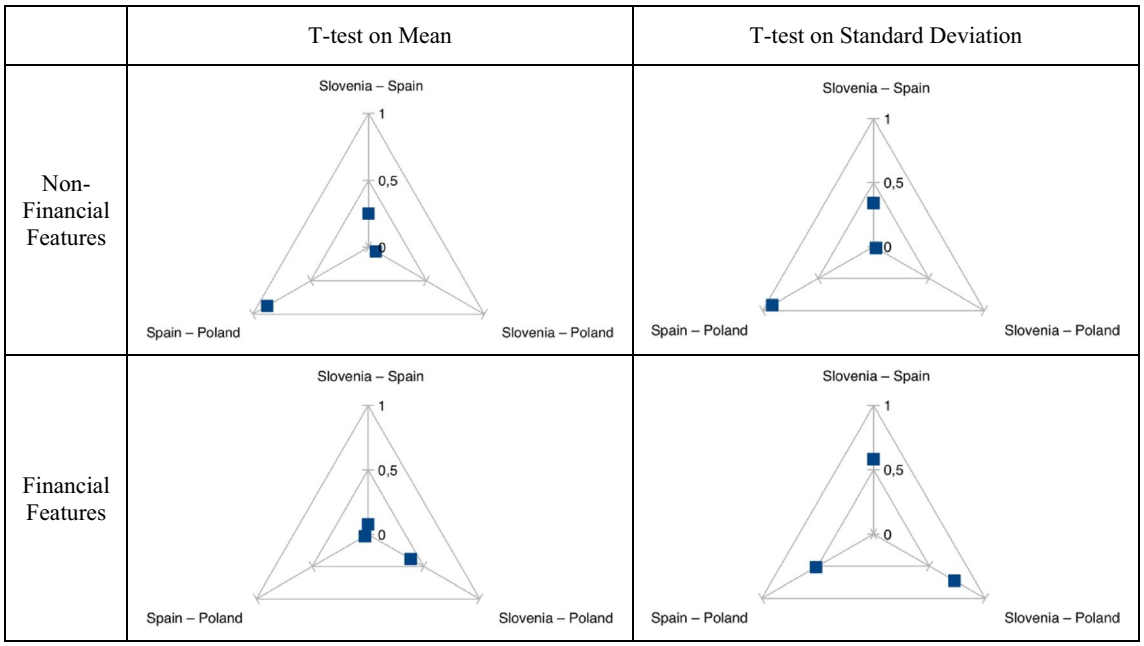


Fig. 3 *T* Tests on mean and standard deviation values of all non-financial and financial features

features differ from each other more than means and more than standard deviations in the case of non-financial features. In our opinion, these differences can be attributed to the subjectivity that affects customer preferences.

Impact of increasing oil price and decreasing ZEV prices

Moreover, the respondents were asked about the influence of petrol and diesel prices on their purchasing decisions. In this case, the analysed data for Slovenia, Spain, and Poland reveal strong similarities among them. Approximately 11 percent of all participants (12% in Spain, 10% in Slovenia, and 9% in Poland) were already seriously considering buying ZEVs at current petrol prices. If petrol prices increased by 30%, approximately 59% of respondents (58% in Slovenia, 62% in Spain, and 55% in Poland) would begin thinking about buying ZEVs, which is a rather high percentage, since a 30% increase in petrol prices over several years is not an unlikely situation. The cumulative results are presented in Fig. 4.

In the period from December 30, 2008, to April 2014, petrol prices in Slovenia increased by 83% (from €0.827/l to €1.514/l). After that, a slight decrease was noted, and in 2017 and 2018, petrol prices increased again within the EU, while in 2019 and 2020, they decreased during an OPEC "oil price war" and in response to the decreased consumption during the 2020 pandemic (approximately €1/l). ZEV sales

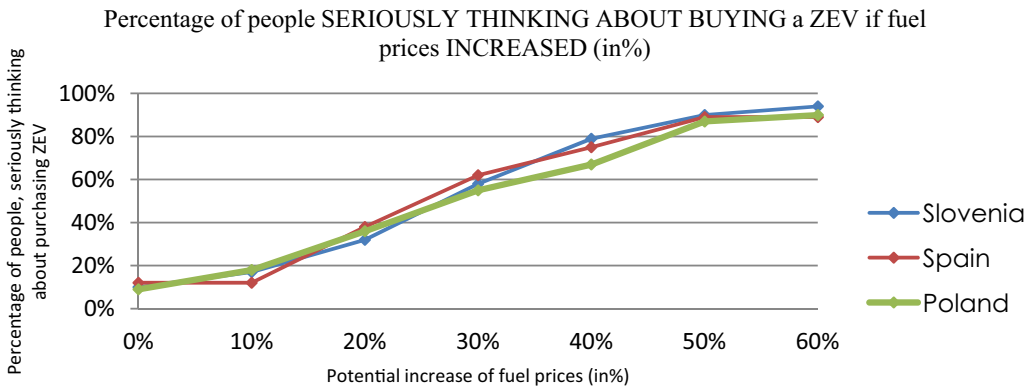


Fig. 4 Dependence of increasing fuel prices on ZEV demand in Slovenia, Spain, and Poland

also increased significantly in the same period. Increasing fuel prices are motivating people to start to considering buying ZEVs since their usage cost is not that dependent or even completely independent of oil prices (Fig. 4). It is also easier to guarantee competitive transportation costs with technologies that are powered by local resources where the EU is not dependent on foreign suppliers. This will probably gain importance in redesigning supply chains after the corona virus pandemic.

Another key finding of this study is that people are more interested in the total price of the car than in different taxes when buying one. A smaller percentage of respondents are already thinking about buying a ZEV despite their slightly higher prices compared to conventional vehicles. However, this research determined that if the prices of environmentally friendlier and (in the long run) economical alternative decreased (by different percentages), the percentage of people seriously thinking about purchasing such a vehicle would significantly increase. The results are presented in Fig. 5.

In Fig. 5, it is once more indicated that respondents from Slovenia and Poland have more similar preferences about decreased prices of ZEV than Spaniards do. Data analysis shows that Spanish consumers are even more interested in potential changes in ZEV prices (especially smaller changes up to 15%) and that the share of potential consumers prepared to consider a ZEV as a real alternative (if its price would decrease) is much higher than in Slovenia and Poland. One possible reason for this is that Spain set ambitious targets for the future uptake of some ZEVs with the primary objective of supporting national and international policies for tackling climate change. In support of these targets, Spain has provided financial support to stimulate both the development and market uptake of these types of vehicles (AEA 2009).

From "No-green" to "Go-green"

Every population comprises different individuals with varying susceptibility levels of changing their behaviour (Anable 2005; Carreno and Welsch 2009); potential ZEV buyers in Slovenia, Poland, and Spain were segmented with cluster analysis. Cluster analysis/segmentation was, therefore, undertaken to identify population segments within the Slovene, Spanish, and Polish driving populations, resulting in three distinct segments with different perceptions of susceptibility to ZEVs, as presented in Table 5.

Based on their response regarding the importance of situational factors and strength of psychological constructs, the following groups/clusters were formed (adapted from Borthwick and Carreno 2012):

- Group one: *No-greens* (almost 20% in Poland, 19% in Slovenia, and 8% in Spain),
- Group two: *Go-with-the-flow greens* (42% in Slovenia, 40% in Poland, and 32% in Spain), and
- Group three: *Go-greens* (60% in Spain, 40% in Poland, and 38% in Slovenia).

Table 5 Diversification of different segments of study participants

Segments/clusters	"No-greens"	"Go-with-the-flow greens"*	"Go-greens"
Are you interested in environmental issues?	No	Yes/No	Yes
Have you considered buying a ZEV in the future?	No	No/Yes	Yes

*The "Go-with-the-flow greens" segment includes participants that are interested in environmental issues OR consider ZEVs in the future but are not interested in environmental issues AND consider buying a ZEV in the future as the "Go-greens" are

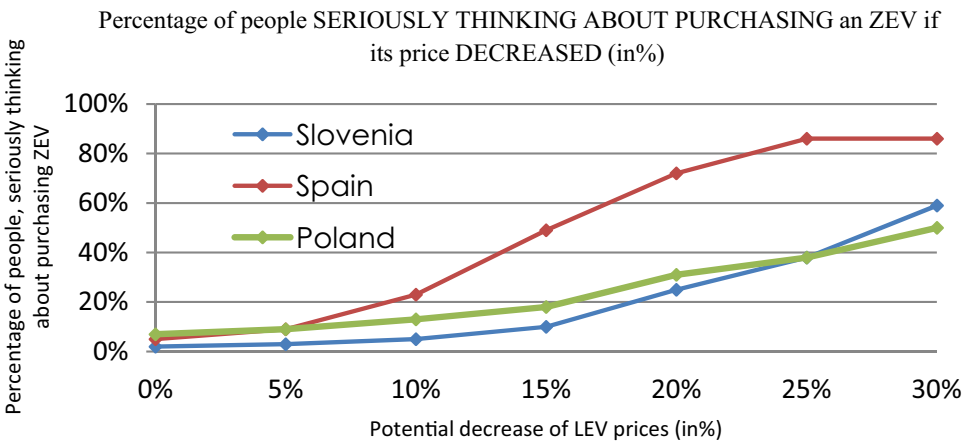


Fig. 5 Percentage of respondents seriously thinking about purchasing a ZEV dependent on potential price decrease of a ZEV

The people in the third group ("Go-green") are very interested in buying a ZEV in the near future, and they are aware of their responsibility to reduce their environmental impact. "Go-with-the-flow greens" are interested in environmental issues or have a positive opinion about ZEVs and are considering buying one because others are talking about it or considering purchasing ZEVs in the future. "No-greens" are not interested in buying a ZEV in the foreseeable future. Information about vehicle emissions is also not a priority when deciding about buying another new or used vehicle.

Figure 6 shows that the share of women is much higher in "Go-green" and "Go-with-the-flow" segments than the share of men. The share of women in the "No-greens" group was approximately one-third that of men in Slovenia and Spain and approximately one-fifth in Poland. This can be noted in all the studied countries; therefore, the authors have concluded that women have a greater interest in ZEVs.

The results are presented in Fig. 7. Differences between countries are significant: 20.7% of the Polish population above 45 years of age can be defined as "No-greens", 5.5% in Slovenia, and none in Spain. The most important difference is that the ratio of "Go-greens" is increasing with age in Slovenia. The distribution of "Go-greens" among different age groups in Poland is very similar, but in Spain, it is the opposite of Slovenia since the ratio of "Go-greens" is decreasing with age. In Spain, the younger population shows a more substantial commitment to the "Go-green" group, but at the same time, there are more undecided or undefined in the middle-aged group. Still, there are no "No-greens" in Spain in the age group of 45 years or more. The "Go-with-the-flow" group (or "undecided") is presumably also the most susceptible to turning into "Go-greens" or "No-greens". The share of the "Go-with-the-flow" group also differs significantly in the studied countries. It is similar in different age groups in Poland but is very different in Slovenia and Spain. The highest population share that has identified themselves as "Go-with-the-flow green" was noted in Spain for the age group of 45 years or more and the lowest in Slovenia for the age group of 35–44 years. The higher importance of CO_2 and other emissions was identified as the main reason for that. Moreover, "Go-with-the-flow greens" are also more concerned about noise emissions.

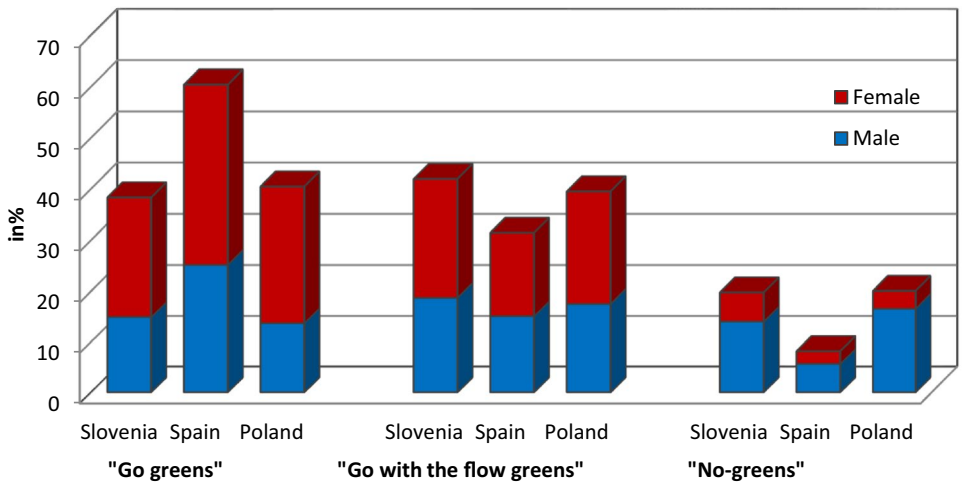


Fig. 6 Segmentation of consumers in Slovenia, Spain, and Poland (male vs. female)

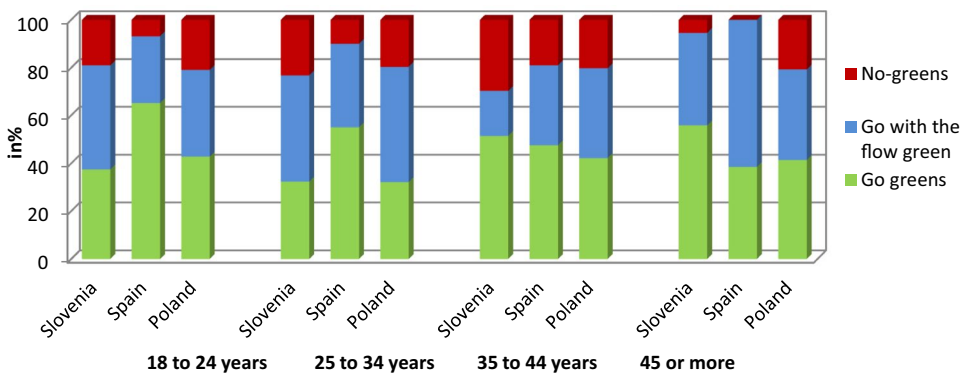


Fig. 7 Segmentation of consumers in Slovenia, Spain, and Poland (age distribution)

Policy measures for ZEV breakthrough

Furthermore, the effect of different measures that encourage people to purchase a ZEV was studied. Table 6 shows that different measures would have different impacts in different countries (e.g. "Parking charges partly based on carbon emissions" are much more important for Spaniards than Slovenians or Poles). The studied measures reflect different possibilities for the promotion of ZEVs, focusing on rewarding them (e.g. with time-saving or pricing incentives). Time-saving measures (e.g. "Low-emission vehicle lane") were evaluated as less important in all three studied countries than pricing incentives (all other studied measures).

According to the results in Table 6, various measures can differently influence people to purchase a ZEV. Differences are also clearly seen among the studied countries. For example, the measure "vehicle scrappage scheme" was defined as the most important measure for the promotion of ZEVs by study participants from all three studied countries. However, the average result in Slovenia was 5.9, in Spain 5.8,

Table 6 Results of different measures that encourage people to purchase a ZEV for Slovenia, Spain, and Poland

Country	Average
VAT based on carbon emissions (i.e. buyers of higher-emission vehicles would pay more VAT)	
Slovenia	**5.3**
Spain	**5.3**
Poland	4.0
First-year rate of road tax derived by a fixed monetary amount (€) per gram of CO_2 (i.e. drivers of low-emission cars pay less)	
Slovenia	**5.0**
Spain	4.9
Poland	3.8
A road user charging scheme based on carbon emissions (i.e. drivers of higher-emission vehicles pay more)	
Slovenia	**5.4**
Spain	5.3
Poland	4.8
A vehicle registration fee based on carbon emissions of the vehicle (i.e. buyers of higher-emission vehicles pay more)	
Slovenia	**5.4**
Spain	5.3
Poland	3.8
Vehicle scrappage scheme with a carbon emissions limit on the replacement vehicle (i.e. one would receive money from the government for getting rid of (scrapping) one old car if one buys a low-emission new car)	
Slovenia	**5.9**
Spain	5.8
Poland	4.7
Annual road tax derived by a fixed monetary amount (€) per gram of CO_2 (i.e. drivers of higher-emission vehicles pay more)	
Slovenia	**5.2**
Spain	5.1
Poland	3.9
Parking charges partly based on carbon emissions (i.e. low-emission cars would pay less to park)	
Slovenia	4.9
Spain	**5.0**
Poland	3.1
"Low-emission vehicle lane" (similar to bus lanes, where low-emission cars would have separate lanes)	
Slovenia	3.7
Spain	**4.3**
Poland	2.8
Motor insurance premiums partly based on carbon emissions (i.e. drivers of higher-emission vehicles pay more)	
Slovenia	5.2
Spain	**5.4**
Poland	3.7

Number in bold are the highest grades among researched countries

On a scale from 1 to 7, where 1 means NOT IMPORTANT and 7 means VERY IMPORTANT

and in Poland 4.7, meaning that even though it is the most important measure, it will probably have a smaller impact in Poland than in Spain and Slovenia. "Low-emission vehicle lane" and "Parking charges based on carbon emissions", in contrast, seem to be more important and potentially more influential in Spain than in Poland and Slovenia. High average scores for many measures indicate that a multiple-measure customer-oriented approach must be used for efficient ZEV promotion.

Study participants from Poland assigned a significantly lower average importance to all measures for the promotion of ZEVs, which could mean that the Polish market is not yet as prepared for ZEVsand that environmental consciousness is lower than in Slovenia and Spain.

Discussion

There were some similarities in identifying the most important financial as well as non-financial features for purchasing ZEVs between Slovenia, Spain, and Poland. Similarities were most visible when comparing Slovenia and Poland, which might be supported by similarities in culture and lifestyle among both studied Slavic countries. However, Poles assigned significantly lower average importance to ZEV promotional policy measures than Spanish and Slovenian participants, which is also consistent with the ZEV sales, which have the lowest share in Poland. One reason for this could also be seen in petroleum prices, which are on average lower in Poland than in Spain and Slovenia.

Different studies, as well as the results of this study, reveal that there is no single measure that would dramatically increase the demand for ZEVs except a large decrease in ZEV prices. Consumer behaviour can be different in different geographic areas (Andre et al. 2018) and can also be non-rational (McCollum et al. 2017). All three governments must be aware that universal measures do not exist and that they are not as effective as customer-oriented measures. While the results are not to be generalized to all EU member states, they provide valuable orientation for emerging research and policy directions. The National Academy of Sciences (2013) report Knez (2017), and Knez and Obrecht (2017) also pointed out that there is no consensus on which policy measures are most effective and influential for the customers' decision-making process. If the governments want to increase interest in purchasing ZEVs, they should adjust and adopt a variety of different measures. As proved by Zhao et al. (2019), the implemented incentive policy must also be dynamic and not static to achieve the best results, so measures should be adapted easily. Zhao et al. also mentioned that the newly launched regulation in China is anticipated to have a huge impact on the development of Chinese as well as global ZEV markets. However, the regulation likely faces the risk of losing this positive effect in approximately 5 years pan or even earlier; therefore, relevant policies should be modified before such a scenario occurs. Taxation as well as policy measures impacting ZEV use and commercialization will thus also vary in the future and must be considered in long-term environmental policies. This comply to the finding that "annual road tax" is not an important issue when considering a new ZEV since it is a relatively small expense in comparison with, for example, the total vehicle price. Regardless, many EU countries proudly promote ZEV with an annual road tax that is related to vehicle emissions. Zhou et al. (2019), for example, argue that the taxation preference had better performance in incentivizing EVs than the direct subsidies, which is contrary to current political discourses.

Cleaner technology acceptance rate and susceptibility to policy measures differ regarding the attitudes and values towards ZEVs. Defined groups of "Go-greens" (with the highest share in Spain), "Go-with-the-flow greens", and "No-greens" (with the highest share in Poland) have shown very small shares of women among "No-greens" in all three studied countries, especially in Spain and Poland. In contrast, men are distributed more equally. Other studies (Borthwick and Carreno 2012; Lina and Wu 2018) also proved that demographics, attitudes, knowledge, values, and behaviour may influence potential intentions to buy environmentally sound products. It is also significant if an engineering and technology background is identified for a potential user since they are more open to buying electric vehicles, for example, than the general public is (Egbue et al. 2017), which might also be one of the reasons why "Go-greens" are more open to ZEVs since we can assume that they are better informed about new clean technologies than other groups are.

Car drivers in all studied countries are more familiar with information about fuel economy and the direct financial consequences of driving than information about a car's environmental influences (e.g. carbon emissions). Recent studies of Cramton et al. (2018) and McCollum et al. (2017) also confirmed that in general, the public is more aware of clean technology financial features instead of environmental impacts. Potential buyers of ZEVs are poorly aware of the meaning of "grams of CO_2 per 100 kms"; therefore, the car manufacturers and retailers, as well as supporting policies for ZEV promotion, should focus on information about how much money could be saved by buying a ZEV.

There are measures that were proven to be successful at limiting and reducing GHG emissions in the transportation sector. Varbanov et al. (2018) also summarize that the GHG emissions EU-28, as well as the USA, have been showing a decreasing trend in recent years. Even the growth rate of Chinese GHG emissions has been slowing down; however, these reductions are not yet enough to reach climate targets. This paper would prove most

successful if awareness of clean technology need is recognized by car manufacturers as well as policy decision-makers. This is particularly relevant in 2020, when the focus and scope of green EU recovery plan challenged by restarting European automobile industry.

Technical limitations of some ZEV, such as insufficient charging infrastructure (for EVs, HFCVs, etc.) or hydrogen storage and V2G concept development within smart communities, and similar, seem to loosen their impact with technological development and greater commercialization. Both the EU and China are focused towards EVs that are up to five times more efficient than internal combustion engines (Duić 2015) and could, therefore, enable more sustainable transportation and efficient use of local resources simultaneously. EVs will also need to deal with battery end-of-life solutions to comply with circular economy principle and the development of comprehensive models for electricity generation, charging, and storage (especially HFCVs) to power cleaner transportation alternatives. The life cycle perspective needs to be studied in detail when choosing future transportation technology priorities on the policy level (Obrecht and Denac, 2016).

Conclusion and outlook

This study provides a practical contribution to the understanding of different features influencing ZEV as a potential technology for cleaner future transportation and the development of supporting environmental policies in Slovenia, Poland, and Spain. Our main findings are that study participants from different countries identified different features as the most important for the promotion of ZEVs and these can determine future policy requirements for ZEV in European countries. There were also significant differences among segments with Spain leading in Gogreens and Poland that seems to be less prepared for ZEV as well as genders since women are in all three studied countries more interested for ZEV than men.

Future research should therefore focus on integrating multiple variables that could boost or decrease interest in ZEV and therefore significantly impact country-specific policy recommendations, such as different geographical conditions (e.g. lowlands, alpine/mountain regions), population density, and climate conditions. Special attention should be oriented towards differences among different regions (e.g. Asia, America, and other EU member and non-member states) to see how different geographically specific and distant potential ZEV users see most potential policy measures as well as ZEV future.

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Affiliations

Matjaz Knez[1] · Borut Jereb[1] · Eulalia Jadraque Gago[2] · Joanna Rosak-Szyrocka[3] · Matevz Obrecht[1]

✉ Matevz Obrecht
matevz.obrecht@um.si

Matjaz Knez
matjaz.knez@um.si

Borut Jereb
borut.jereb@um.si

Eulalia Jadraque Gago
ejadraque@ugr.es

Joanna Rosak-Szyrocka
joanna.rosak-szyrocka@wz.pcz.pl

[1] Faculty of Logistics, University of Maribor, Mariborska cesta 7, 3000 Celje, Slovenia

[2] Escuela Técnica Superior de Ingeniería de Caminos, Universidad de Granada, Canales y Puertos, Avenida Severo Ochoa s/n, 28071 Granada, Spain

[3] Faculty of Management, Institute of Production Engineering, Czestochowa University of Technology, al., Armii Krajowej 19 B, 42-201 Czestochowa, Poland